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THE PERSPECTIVE ABILITY TEST INVOLVED 285 CHILDREN BETWEEN 66 AND 155 MONTHS OF AGE. TO MEASURE ABILITY TO COORDINATE PERSPECTIVE, THE RESEARCHER BUILT A CIRCULAR TABLE WITH AN ISLAND DISC MODELED AND PAINTED TO REPRESENT WATERS AND MOUNTAINOUS LAND. TWENTY COLOR PHOTOGRAPHS WERE TAKEN FROM DIFFERENT EQUALLY SPACED VANTAGE POINTS. THE SUBJECTS WERE ASKED TO STAND IN ONE PLACE AND INDICATE WHERE THE CAMERA HAD TO HAVE BEEN WHEN A PARTICULAR PICTURE WAS TAKEN. THE DATA INDICATE THAT THERE WAS A PROGRESSION FROM HIGHER TO LOWER ERROR SCORES AS THE AGE OF THE CHILDREN INVOLVED INCREASED. THE TEST APPEARED TO BE A REASONABLY RELIABLE AND PRECISE INSTRUMENT FOR ASSESSING CHANGE IN ABILITY TO COORDINATE PERSPECTIVES AS THE CULMINATION OF DEVELOPMENTAL PROCESSES. AT THE TIME OF THE STUDY RESEARCH WAS UNDERWAY FOR FURTHER INVESTIGATION OF NORMAL TRENDS AND VARIABILITY IN TIME REQUIRED FOR ACQUISITIONS OF SPATIAL ABILITY AND DETERMINING THE FEASIBILITY OF SPECIAL TRAINING TO ACCELERATE OR MAKE MORE PRECISE THE ABILITY TO COORDINATE PERSPECTIVES. (CO)

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Development of Children's Ability to Coordinate Perspectives*

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Background

There is a basic need in every field for precise data on when and by what means individuals acquire the concepts and capabilities essential to mature operations. In the field of geography, we have a continuing need for research into the process and sequence by which spatial concepts are developed in children and young adults. This paper describes the design and trial of an instrument for measurement of ability to coordinate perspectives. Simply stated, the ability to coordinate perspectives signifies an understanding that objects and groups of objects will appear different from different vantage points; plus the ability to, in effect, superimpose a mental grid system on an area and thereby predict what would be seen from a variety of viewpoints other than the one currently occupied.

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Piaget and Inhelder

Coordination of perspectives has been labelled and discussed in some detail by Piaget and Inhelder in Chapter VIII of The Child's Conception of Space.[1] The Genevan group regards ability to coordinate perspectives as the culmination of a long developmental process; they have identified five distinct stages and sub-stages of perspective development between four and ten years of age. While the Piaget-Inhelder studies indicate limited capacity to handle the concept of differing viewpoints after the seventh birthday, mature conceptualization of one's immediate view as only a single example from a large and coordinated system of viewpoints does not appear for most children before the ninth or tenth birthday. Mention is made of some children being advanced, carrying the implication that while sequence is regarded as constant for all individuals actual time of acquisition might show considerable variability. As is frequently found in Piaget's work, the sample studied or amount of variation found is not described in great detail. However, we are informed that the research involved 100 children between four and one-half and twelve years of age.

Development of the Perspective Ability Test

In the investigations described by Piaget and Inhelder, a child was shown a model of three mountains and first asked to use cardboard representations to show how the mountains would appear from various positions other

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1. Jean Piaget and Barbel Inhelder. The Child's Conception of Space. New York: W. W. Norton and Co., 1967 (First published in France, 1948). Piaget and Inhelder state that Chapter VIII was written in collaboration with Mlle Edith Mayer.

than his own. Later the child was asked to identify the positions from which a series of photographs of the mountains had been taken. Children in the youngest group could only conceptualize or represent whatever view they had of the model at a given time; children ten years of age or older were able to perform both kinds of tasks with relative ease.

Since publication of the space volume in 1948, there undoubtedly have been several investigations where some variation of the three-dimensional map test was employed. Professor Eliot, for example, reported use of rectangular, three-dimensional maps and black and white photographs in both his 1963 and his 1966 training studies.[2]

While we are interested ultimately in instructional strategies for the development of spatial concepts, an initial goal has been the construction and trial of a measure of perspective ability. We have taken the basic task developed by Piaget and his colleagues and have recast it into a more standardized and, hopefully, precise instrument. First, a circular table (See photographs) was built to avoid the kinds of sighting suggestions implicit in the lines and angles of a square or rectangular model. Then a fictitious island group was built on a removable disc in the table top and was painted in "realistic" colors to represent waters and mountainous land. Suitable landmarks, although without man-related structures, were provided to help the viewer differentiate each island from its neighbors. Subsequently, twenty color photographs of the table were taken from vantage points separated

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2. John Eliot. Report on a Spatial Relations Unit and Perspective Test. Cognitive Study of Basic Geography Project. Boston: Council for Public Schools, 1963; The Effects of Age and Training Upon Children's Conceptualization of Space. Stanford University Doctoral Dissertation, 1966.

by exactly 18 degrees on the circumference of the table. Elevation of the camera above the table also was carefully controlled. Following this, three-inch white circles were placed on the surface of the table near the outer edge to mark the twenty camera positions. Each circle had an identifying letter, from A through T, pointed on it in a contrasting black.

Test Procedures[3]

Subjects were introduced to the map table with the explanation that it showed a group of imaginary islands and that a series of color slides had been taken of it. The child was asked to stand near the table opposite circle H, to look at each slide as long as necessary, and to indicate where the camera had to be when that picture was taken. When the child had responded to ten of the twenty slides, he was asked to step to another point 90 degrees along the edge of the table (opposite position N) and respond in a like manner to slides eleven through twenty. Although the session was rather informal and children were urged to take whatever time they needed, actual time at the map table was comparatively short; 95 per cent of the children took from 2-9 minutes to respond to the twenty slides.

Scoring was in terms of error from the correct camera position for each photograph. A minus 3 score, for example, indicated three positions (or a total of 54 degrees) of error to the left for that item. Taking the composite of the twenty items, it was possible to obtain both measures of Gross Error, with a possible maximum of 200 points, or of tendencies to make a disproportionate number of errors to the left or the right.

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3. The descriptions provided here are necessarily abbreviated. Researchers interested in use of a similar device may contact the author for more complete descriptions of the map table, testing procedures, score sheets, and the like.

Sample

Some 285 children, from 66-155 months of age, have taken the Perspective Ability Test and are included in this report. A majority were regular pupils at the Peabody Demonstration School--although a number of children registered for the 1967 summer session also were included. Many of the latter group were remedial cases; their inclusion undoubtedly raised the mean error score and within group variability at some age levels.

Results

Means and variances for the 285 subjects, divided into fifteen six-month age groups, are shown in Table 1. The group means also are shown graphically in Figure 3. As these data indicate, there is evidence of a progression from higher to lower error scores as children become older. The progression is uneven, however. Correlation between error scores and age is -.30.

Piagetan theory would indicate that a break of some sort might be expected as children leave the period of pre-operational thought and progress into the period of concrete operations. One way to search for such a break or rapid increase in slope was to run a series of orthogonal comparisons between a given age group and all older groups. Results of such comparisons up the age ladder appear in Table 2. The data indicate a change at about the seventh birthday, or about where Piaget hypothesized the change from pre-operational to concrete operational thought. The change was not so abrupt, however, that a *t* test between Group 3 (those between six and one-half and seven years of age) and the next six-month age group was significant at the .05 level. A *t* test between combined Groups 1-3 and combined Groups 4-6 was significant at the .05 level, however.

While the difference between the mean error score of Group 8 (108-113 months) and that of all older subjects was not significant, a t test comparison with the mean of Group 9 reveals a drop significant at the .05 level. We are reluctant to make too much of this difference--because of the irregular pattern among some of the older age groups--but it does coincide rather closely with Piaget's Stages IIIA and IIIB in development of ability to coordinate perspectives.[4]

A number of other comparisons were made. One explored the relationship between time spent on the test and gross error score of the subjects. The answer seems to be that there was none; the correlation was .05 for the 285 cases. Orthogonal comparisons up the ladder from least time (slightly under two minutes) to the most time (about twenty-one minutes), grouped by half-minute intervals, revealed no significant F-ratios.

Another comparison sought to discover any tendency on the part of individuals (such as those with left or mixed lateral dominance) to make a disproportionate percentage of errors to left or right. Left and right errors were counted for each of the subjects and probabilities computed using the binomial distribution. Of the 285 children, only 13 (4.56 per cent) had either left or right biases within the .05 level of probability. A further check was made by pooling probabilities for the entire sample, using Fisher's technique.[5] The Chi Square value of 461.79 was not close to the critical value of 626.65. Neither analysis suggested any tendency toward consistent left or right errors. There was no reason to believe

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4. The Child's Conception of Space. Pp. 233-246.
5. R. A. Fisher. Statistical Methods for Research Workers. Fifth edition. Edinburgh: Oliver and Boyd, 1934. P. 103.

that laterality or any other factor caused systematic error on one side or the other of correct position.

Error scores of girls and boys at various grade levels (kindergarten-fourth and sixth grades) were compared through use of t tests. Of the seven grade level comparisons, involving 175 subjects, only one comparison was significant at the .05 level. This was at sixth grade level; the girls had significantly higher error scores than the boys. We might have dismissed this difference as a function of probability building up through multiple comparisons; however, in the light of Sherman's recent review indicating basic sex differences in spatial perception--differences which seem to intensify with the on-set of adolescence--we intend to explore again the possibility of sex differences at higher age levels.[6]

Reliability of the test, reported earlier in The Journal of Geography, has been encouraging.[7] A group of 22 first grade children took the test in two forms, first with color photographs mounted on cards and a month later with slides projected on a screen. Considering the relatively young age of the subjects (75-90 months), the change in test forms, and the lapse of time, a rather low correlation was anticipated. Instead, we found the correlation between gross error scores for the boys on the two testings to be .91, girls .70, and girls and boys combined .79. This stability was also confirmed by an analysis of variance over the differences between sex, test form and time lapse, and interaction of these factors--there were no differences significant at the .05 level. Indeed, the differences were so small as to be virtually nonsignificant even at the .50 level.

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6. Julia A. Sherman. "Problem of Sex Differences in Space Perception and Aspects of Intellectual Functioning." Psychological Review, Vol. 74, No. 4, 1967. Pp. 290-299.

7. Jack W. Miller. "Measuring Perspective Ability." The Journal of Geography, Vol. 66, No. 4, April 1967. Pp. 167-171.

Summary

Taken together, our investigations tend to substantiate the findings of Piaget and his associates regarding children's ability to deal with perspectives. The map test appears to be a reasonably reliable and precise instrument--either for the assessment of change in ability to coordinate perspectives after training or for continuation of normative studies in the general or special populations. At the present time we have research underway in both areas: (1) Further investigations of normal trends and variability in acquisition of this spatial ability and (2) studies to determine the feasibility of special training to accelerate or make more precise the ability to coordinate perspectives.

Table 1: Perspective Ability Test Means and Variances for 285 Subjects, 66-155 Months in Age and Grouped by Six-Month Age Intervals

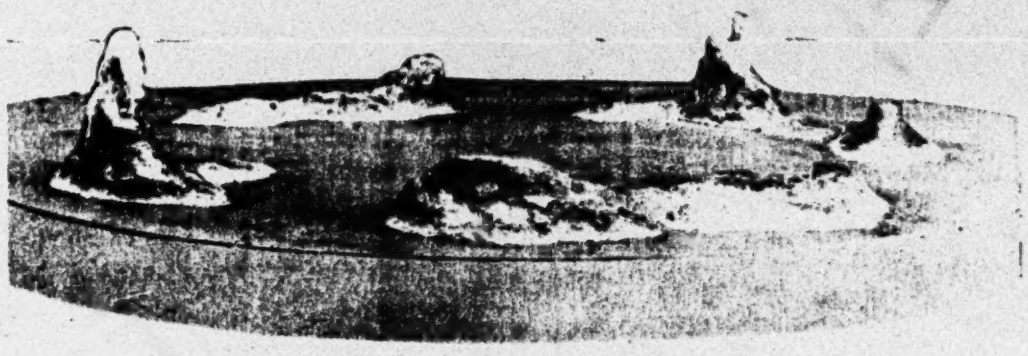
Group	Age in Months	Number	Mean Gross Error Score on the PAT	Group Variance
1	66-71	10	88.50	394.72
2	72-77	21	83.95	346.25
3	78-83	16	78.62	761.18
4	84-89	20	62.05	784.47
5	90-95	17	57.71	649.10
6	96-101	15	55.80	825.03
7	102-107	17	56.59	261.76
8	108-113	30	57.60	789.42
9	114-119	17	43.76	324.94
10	120-125	17	45.53	575.51
11	126-131	15	53.60	1244.11
12	132-137	30	37.77	333.77
13	138-143	39	37.33	409.60
14	144-149	16	47.00	1287.33
15	150-155	5	38.80	1529.20
Combined Groups:		285	54.43	623.38

Table 2: Orthogonal Comparisons of Gross Error Scores of Younger Versus All Older Age Groups, Perspective Ability Test

Orthogonal Comparison	Sums of Squares	F-Ratios
Group 1 Against Groups 2 to 15	12031.11	19.30**
Group 2 Against Groups 3 to 15	14023.98	22.50**
Group 3 Against Groups 4 to 15	4018.08	6.45*
Group 4 Against Groups 5 to 15	939.73	1.51
Group 5 Against Groups 6 to 15	283.53	.46
Group 6 Against Groups 7 to 15	135.76	.22
Group 7 Against Groups 8 to 15	185.57	.30
Group 8 Against Groups 9 to 15	611.43	.98
Group 9 Against Groups 10 to 15	2.09	.00
Group 10 Against Groups 11 to 15	7.71	.01
Group 11 Against Groups 12 to 15	50.19	.08
Group 12 Against Groups 13 to 15	2.19	.00
Group 13 Against Groups 14 to 15	5.21	.01
Group 14 Against Group 15	.06	.00

**Significant at the .01 level.
*Significant at the .05 level.

Figure 1 (Right): Map as photographed from 20 positions around its circumference, each of the pictures 18 degrees from its neighbors.



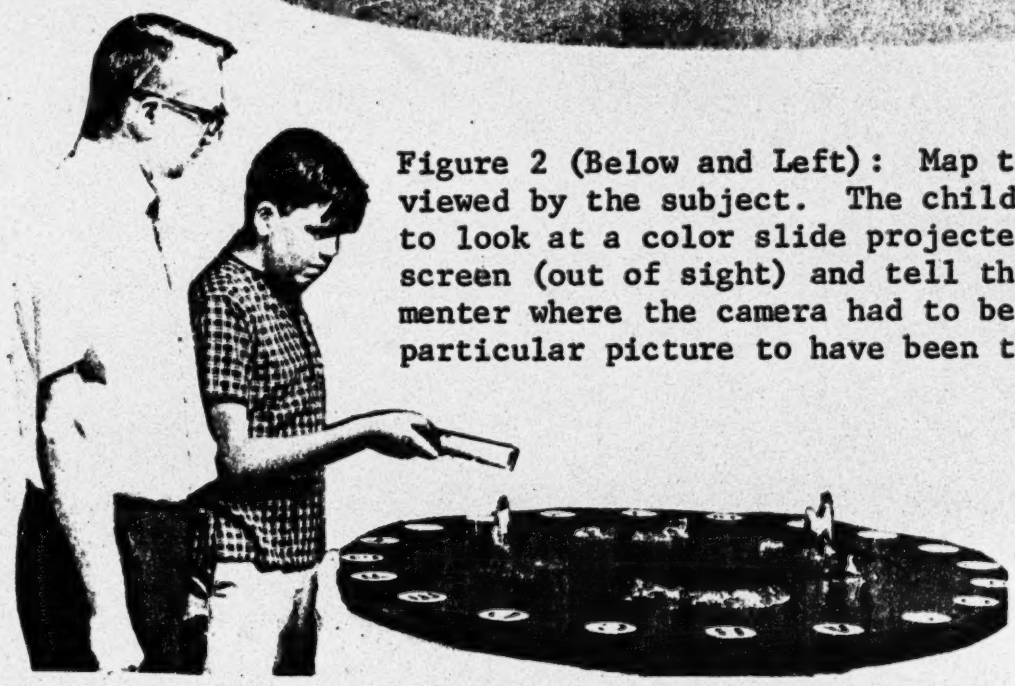


Figure 2 (Below and Left): Map table as viewed by the subject. The child is asked to look at a color slide projected on the screen (out of sight) and tell the experimenter where the camera had to be for that particular picture to have been taken.

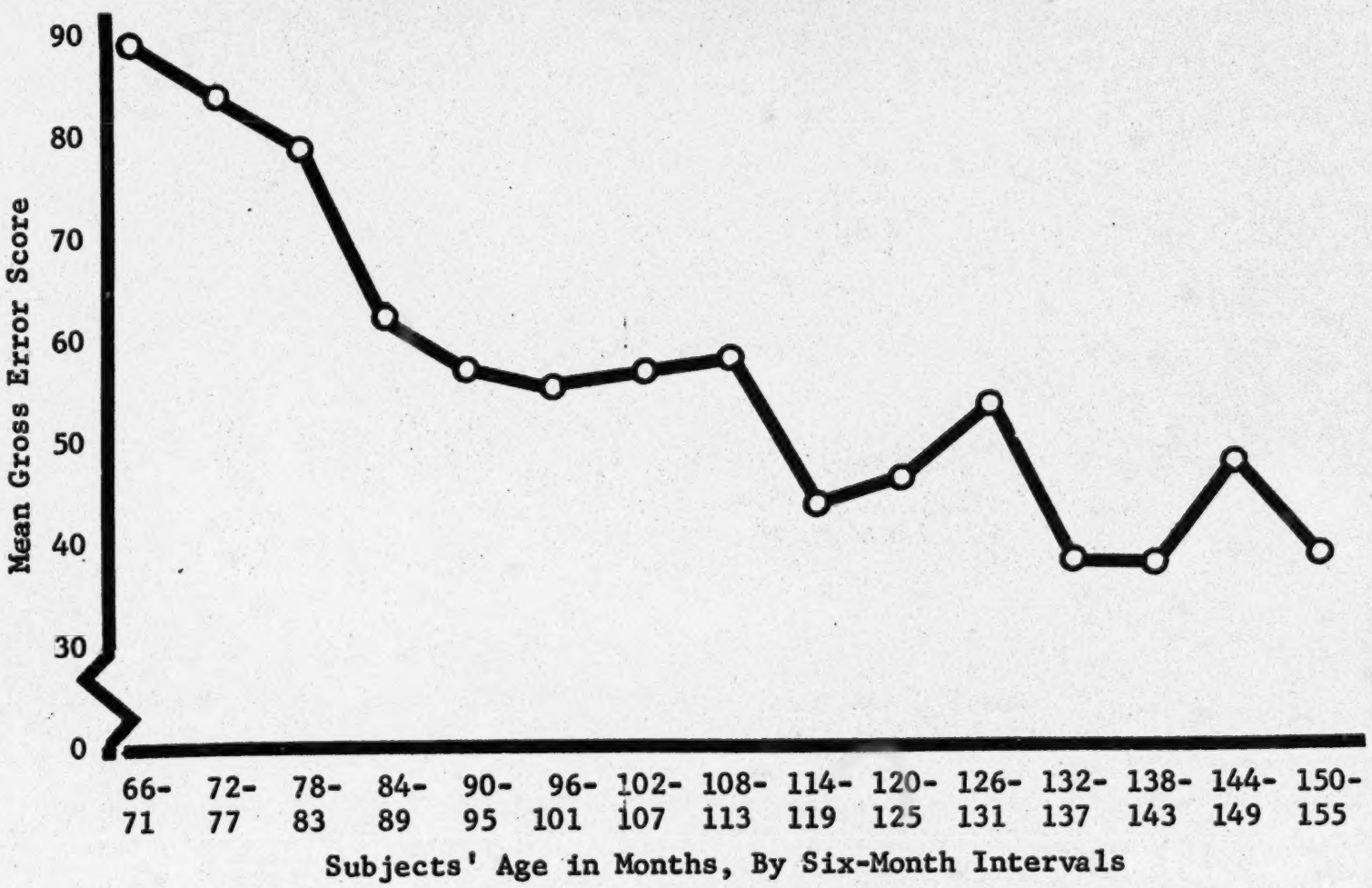


Figure 3. PAT Gross Error Means For Six Month Age Groups